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APPLICATION FOR UNITED STATES LETTERS PATENT

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TITLE:	HEAT EXCHANGER TUBE WITH STONE PROTECTION APPENDAGE
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HEAT EXCHANGER TUBE WITH STONE PROTECTION APPENDAGE

BACKGROUND OF THE INVENTION

Field Of Invention

The present invention relates generally to a heat exchanger tube for use in a heat exchanger and, more particularly, to a heat exchanger tube with a stone protection appendage.

Discussion Of Related Art

Fig. 1 shows a cross-sectional view of a conventional heat exchanger flat tube of this kind. The heat exchanger tube 11 is made by extruding an aluminum article. The tube 11 has a peripheral wall 12 having an elongated circular cross-sectional shape and a plurality of divisional walls 13, 13a connecting flat wall portions 12a of the peripheral wall 12. The divisional walls 13 divide an inside space of the tube 11 to form a plurality of unit passages 14, 15 arranged in a lateral direction of the tube 11. Each divisional wall 13, 13a has a constant thickness along the height thereof so that a contact area with the heat exchanging medium can be enlarged, thereby enhancing the heat exchanging performance of the tube 11. The tube 11 includes outermost unit passages 14 and intermediate unit passages 15 located between the outermost unit passages 14. Each intermediate unit passage 15 has a rectangular cross-sectional shape, and each outermost unit passage 14 has a semi-circular cross-sectional shape at a lateral outside portion and a rectangular cross-sectional shape at lateral inside portion. Further, each portion of the tube 11, i.e., the peripheral wall 12 and the divisional walls 13, 13a, are formed to be as thin as possible for the purpose of lightening the weight of the tube 11.

Further, when the above-mentioned tube 11 is used in a condenser mounted in an automobile, tube 11 may sometimes become damaged and cause leakage of the heat exchanging medium when a stone, or the like, hits the tube 11 while the automobile is moving.

BRIEF SUMMARY OF THE INVENTION

Two objects of the present invention are to provide both protection of the tube body against a stone or the like which hits the tube, and an excellent heat exchanging performance by keeping a large contact area with a heat exchange medium.

According to one aspect of the present invention, the above-referenced objects can be achieved for use in a vehicle by a heat exchanger tube extending in an axial direction that has an end. The end has a first and second appendage attached to it, such that, the first appendage and the second appendage are spaced from one another and the second appendage does not form an enclosed space with the first appendage.

According to another aspect of the present invention, the above-referenced objects can be achieved for use in an automotive air conditioner by a heat exchanger tube extending in an axial direction that has an end. The end has a first and second appendage attached to it, such that, the first appendage and the second appendage are spaced from one another and the second appendage does not form an enclosed space with the first appendage.

Each of the above aspects of the present invention protects the tube's body from being damaged by the use of the nose-tip-appendage. So that when an object, such as a stone, hits the tube, the nose-tip-appendage would collapse, absorbing the energy of the incoming object. Furthermore, although the present invention may be used in an automotive air conditioner, the present invention may also be used in a radiator oil cooler and, as stated above, the present invention may also be use in a residential heat exchanger.

Additional aspects and advantages of the present invention will become apparent from the following description and the appended claims when considered with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a cross-sectional view of a known heat exchanger tube;

Fig. 2A shows a cross-sectional view of a first embodiment of a heat exchanger according to the present invention;

Fig. 2B shows an enlarged cross-sectional view of the heat exchanger tube of Fig. 2A;

Fig. 3 shows a cross-sectional view of a second embodiment of the heat exchanger tube;

Fig. 4 shows a cross-sectional view of a third embodiment of a heat exchanger tube according to the present invention;

Fig. 5 shows an alternate configuration of the heat exchanger tube of Fig. 4, according to the present invention;

Fig. 6 shows front view of an embodiment a heat exchanger that includes one of the heat exchanger tubes of Figs. 2-5 according to the present invention;

Fig. 7A shows an embodiment of an automobile with a heat exchanger having one of the heat exchanger tubes of Figs. 2-5 according to the present invention; and

Fig. 7B shows a residential home with an air conditioner having one of the heat exchanger tubes of Figs. 2-5 according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 6 shows a heat exchanger of a so-called multi-flow type that includes a plurality of multi-bored flat tubes 1 each having a certain length, fins 2 interposed between the tubes 1, and a pair of hollow headers 3 to which the ends of the tubes 1 are connected. Each header 3 is divided by a partition 4. In operation, medium flows into the right hand header 3 through an inlet 5 connected to the upper portion of the header, passes through the left hand header 3 through an outlet 6 connected to the lower portion of the header 3.

Fig. 2A shows an embodiment of a heat exchanger tube 20 of used in a vehicle. The heat exchanger tube 20 is an aluminum extruded article. As shown in Figs. 2A and 2B the heat exchanger tube 20 extends in an axial direction and has nose ends 21. The typical length L of the heat exchanger

tube 20 is designed to be in the range of 10.0 mm to 25.0 mm. A peripheral wall 22 is formed to have an elongated circular cross-sectional shape. A plurality of divisional walls 23 are provided in the heat exchanger tube 20 to form a plurality of compartments 24, 24a arranged in the axial direction of the heat exchanger tube 20. The divisional walls 23 connect flat wall portions 25 of the peripheral walls 22 with each other at a certain distance. The thickness t1 of divisional walls 23 can be designed to be in the range of 0.15 mm to 0.45 mm while the thickness t2 of the flat wall portions 25 is designed to be in the range of 0.27 mm to 0..60 mm.

The inner surface of each of the outermost compartments 24a is formed to be a circumferentially smooth curved shape in cross-section. In this embodiment, each compartment 24a is formed to have a rounded, or semicircular, inner surface at the outermost compartment side and a rectangle at the other side. The width cw of compartment 24a is typically from 0.30 mm to 3.0 mm. The height ch of compartment 24a is typically from 0.6 mm to 3.5 mm. However, the compartment 24a may be formed to be an elongated circular cross-sectional shape, an elliptical shape or a perfect circular shape.

The plurality of inner compartments 24 are typically formed to be rectangular in shape in cross-section. The width w of an inner compartment 24 is typically designed to be 1.4 mm. However, the inner compartments 24 are not constrained to be rectangular in shape in cross-section. The inner compartments 24 can be designed to have a triangular, a trapezoidal, circular, or a star shape. A particular advantage of the present invention, in any embodiment, is that design of a major portion of the heat exchanger tube 20 is irrelevant as described below.

Attached to each of the nose ends 21 are appendages 26a, 26b. Each of the appendages 26a, 26b are spaced from one another such that appendage 26a and appendage 26b do not form an enclosed space with one another. In this embodiment, each of the appendages 26a, 26b are substantially straight and are integrally formed from the flat wall portions 25. The appendages 26a, 26b are also substantially parallel to each other. The

thickness t3 of each of the appendages 26a, 26b is designed to be from 0.2 mm to 0.5 mm. While the thickness t4 of each of the nose ends 21 is typically in the range of 0.30 mm to 0.65 mm. Each of the appendages 26a, 26b extends 0.5 mm from nose ends 21. The height h, as measured from the top of appendage 26a to the bottom of appendage 26b is designed to be 2.01 ± 0.04 mm.

When the above-mentioned heat exchanger tube 20 is used in a condenser for an automobile air conditioner, the heat exchanger tube 20 may be hit by an object, such as a stone, that is passed through a radiator grill of the automobile. In this case, however, the appendages 26a 26b prevent the nose ends 21 from being damaged because typically the appendages 26a, 26b on the windward side of the heat exchanger would be hit first and collapse, absorbing the energy of the incoming stone, therefore, protecting heat exchanger tube 20.

Fig. 3 shows another embodiment of heat exchanger tube 20. In this embodiment, the straight appendages 26a, 26b of Fig. 2A have been replaced by appendages 31.

Appendages 31 are attached to the center of nose ends 21. In this embodiment, appendages 31 are substantially straight and are integrally formed from the nose ends 21. Appendages 31 extend 0.5 mm from the tip of nose ends 21 and typically have a thickness t5 of 0.44 mm.

When the above-mentioned heat exchanger tube 20 is used in a condenser for an automobile air conditioner, the heat exchanger tube 20 may be hit by an object, such as a stone, that is passed through a radiator grill of the automobile. In this case, however, the appendages 31 prevent the nose ends 21 from being damaged because typically the appendage 31 on the windward side of the heat exchanger would be hit first and collapse, absorbing the energy of the incoming object, therefore, protecting heat exchanger tube 20.

Fig. 4 shows another embodiment of heat exchanger tube 20, according to the present invention. In this embodiment, the straight

appendages 26a, 26b of Fig. 2A have been replaced by appendages 41a, 41b, respectively.

Appendages 41a, 41b are attached to nose ends 21. Each of the appendages 41a, 41b are spaced from one another such that appendage 41a and appendage 41b do not form an enclosed space with one another. In this embodiment, each of the appendages 41a, 41b are curved with a radius of curvature of typically between 0.6 and 1.5 and are integrally formed from the flat wall portions 25. The appendages 41a, 41b also face each other and end in a point. Each of the appendages 41a, 41b extend 0.5 mm from nose ends 21. The space S between each appendage 41a, 41b is preferably 1.0 mm.

When the above-mentioned heat exchanger tube 20 is used in a condenser for an automobile air conditioner, the heat exchanger tube 20 may be hit by an object, such as a stone, that is passed through a radiator grill of the automobile. In this case, however, the appendages 41a, 41b prevent the nose ends 21 from being damaged because typically the appendages 41a, 41b on the windward side of the heat exchanger would be hit first and collapse, absorbing the energy of the incoming object, therefore, protecting heat exchanger tube 20. This embodiment of the present invention provides the superior protection for heat exchanger tube 20 because of the size of space S, stones greater than or equal to 1.0 mm cannot damage the heat exchanger tube 20.

Fig. 5 shows an alternate configuration of the embodiment as shown in Fig. 4 of heat exchanger tube 20, according to the present invention. In this embodiment, the straight appendages 26a, 26b of Fig. 2A have been replaced by appendages 51a, 51b.

Appendages 51a, 51b are attached to nose ends 21. Each of the appendages 51a, 51b are spaces from one another such that appendage 51a and appendage 51b do not form an enclosed space with one another. In this embodiment, each of the appendages 51a, 51b are curved with a radius of curvature of typically between 0.6 and 1.5 and are integrally formed from the flat wall portions 25. The appendages 51a, 51b also face each other and end in a flat part 52. Each of the appendages 51a, 541b extend 0.5 mm from

nose ends 21. The space S between each appendage 51a, 51b is preferably 0.79 mm.

When the above-mentioned heat exchanger tube 20 is used in a condenser for an automobile air conditioner, the heat exchanger tube 20 may be hit by an object, such as a stone, that is passed through a radiator grill of the automobile. In this case, however, the appendages 41a, 41b prevent the nose ends 21 from being damaged because typically the appendages 41a, 41b on the windward side of the heat exchanger would be hit first and collapse, absorbing the energy of the incoming object, therefore, protecting heat exchanger tube 20. This embodiment of the present invention provides the maximum protection for heat exchanger tube 20 because of the size of space S, stones greater than or equal to 0.79 mm cannot damage the heat exchanger tube 20.

As schematically shown in Fig. 7A, the heat exchanger tubes of Figs. 2-5 and the heat exchanger 7 of Fig. 6 can be installed in an automobile 70, where the heat exchanger 7 is part of the cooling system and/or air conditioning system of the automobile. In addition, the heat exchanger tubes of Figs. 2-5 and heat exchanger 7 of Fig. 6 can be installed in an air conditioning unit positioned within a residence 71 of Fig. 7B.

The foregoing detailed description is merely illustrative of several physical embodiments of the invention. Physical variations of the invention, not fully described in the specification, may be encompassed within the purview of the claims. Accordingly, any narrower description of the elements in the specification should be used for general guidance, rather than to unduly restrict any broader descriptions of the elements in the following claims.